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MAGNETISM

ESR and Mössbauer Spectroscopic Study of Sr-Doped Ytterbium Ferromanganites

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Abstract—In this paper, we have studied the crystal structure of strontium-substituted manganite and ytterbium ferromanganites $Yb_{0.82}Sr_{0.18}Mn_{1-x}Fe_xO_3$ ($x = 0$–0.2) by using X-ray diffraction analysis. Magnetic microstructure has been studied by electron paramagnetic resonance and nuclear gamma-resonance (Mössbauer) spectroscopy. We have observed phase separation in the ceramics for antiferromagnetic, superparamagnetic, and ferromagnetic phases.

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1. INTRODUCTION

The substitution of a trivalent lanthanide element in manganites of rare-earth elements (REE) leads to the splitting of the magnetic subsystem of the samples into ferro- and antiferromagnetic components. A magnetically nonphase state in solid solutions of $R_{1-y}A_yMnO_3$, where R is a rare-earth cation and A is a divalent cation, arises in these compounds due to the frustration of magnetic moments caused by the competition of ferromagnetic and antiferromagnetic interactions close to each other in magnitude. The suppression of frustrations of magnetic moments by an external field and the transition of the system to a magnetosingle-phase state causes abnormally high values of galvano- and thermomagnetic phenomena in rare-earth manganites [1]. Ferromagnetic clusters appear in both the antiferromagnetic and paramagnetic matrix. Such a magnetic phase separation in barium, calcium, and strontium-substituted lanthanum manganites has been earlier observed by ESR [2–4] while the separation in the ferromanganites of lanthanum and neodymium, $Ln_{1-y}A_yMn_{1-x}Fe_xO_3$ (A = Pb, Sr; Ln = La, Nd) has been found by Mössbauer spectroscopy [5, 6]. The aim of this work has been to study the structural and magnetic properties and Mössbauer and ESR spectra of strontium-substituted ytterbium ferromanganites. Unlike the manganites of europium, lanthanum, and neodymium, manganites of "heavy" lanthanides crystallize in an ilmenite-like lattice. Partial substitution in the 3d-sublattice of the manganese cations for iron makes it possible to study the samples by Mössbauer spectroscopy on the ^{57}Fe isotope, i.e., to obtain information on the type of magnetic ordering, supplementing the data obtained by ESR.

2. EXPERIMENTAL

According to standard ceramic technology, the samples of strontium-substituted ytterbium ferromanganites have been synthesized from the mixture of parent oxides taken in the stoichiometric ratio. The mixture has been additionally enriched with the isotope ^{57}Fe by 30–50%. Sintering has been carried out in three stages at 1223, 1323, and 1423 K, respectively, during 8 h each with an intermediate grinding of the ceramic. More details on the synthesis of samples have been described in [7]. X-ray diffraction analysis has been performed by using a Rigaku Smart Lab diffractometer with a Cu-anode tube in discrete mode in 0.04° increments. Mössbauer spectra have been obtained at 295, 170, and 80 K. Spectrum parameters have been calculated using the standard UNIVEM MS program. Measurements of the ESR spectra have been carried out by using a Bruker EMX spectrometer at 9.4 GHz in a temperature range of 100–320 K.

3. RESULTS AND DISCUSSION

X-ray Diffraction Analysis

Based on the data obtained by X-ray diffraction analysis (XRD), all samples have had the ilmenite structure ($P6_3cm$ space group). The diffractogram of $Yb_{0.82}Sr_{0.18}Mn_{0.85}Fe_{0.15}O_3$ is shown in Fig. 1. Table 1 shows the parameters of the crystal lattice of the samples.